
Factors Influencing Variations in Distribution of Dental Manpower in an Urban Area

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HUMAN ECOLOGISTS, urban planners, and other social scientists have been concerned with the factors associated with the distribution of human activity in time and space. A rather large body of literature exists on why certain forms of social organization tend to develop more readily in some geographic areas than others or to distribute in different patterns throughout the nation. Several theoretical constructs have been devised to explain variations in the distribution patterns for all types of industries, institutions, and organizational forms.

These theoretical perspectives have been applied to the study of service industries to demonstrate that tertiary industries that sell products directly to the ultimate consumers will locate where the consumers are. More specifically, service industries tend to concentrate and prosper in areas having sufficient population density and where the educational and income levels of the population are relatively high (1-3). This perspective applies also to medical and dental services.

National and regional studies on the distribution of medical and dental services have been conducted by Marden (4), Rimlinger and Steele (5), Tryon (6), and Boudreau (7). The findings of these investigators indicate that physicians and dentists are distributed in patterns similar to population size, per capita personal income, education, and other socioeconomic characteristics. Generally, the supply of medical manpower varied directly with the size and socioeconomic status of the populations in the areas studied.

Although several intrametropolitan studies (8-10) found that in some areas population size and characteristics account for a sizable proportion of the variance in the distribution of health services, the results of these and other studies suggest that other factors may have some impact on distribution. In fact, urban land use, transportation, and other economic and geographic factors may be more important in determining where health services locate than the variables traditionally used in urban analyses.

Distribution of Dental Services

A variety of variables have been used in numerous studies of factors influencing the distribution of dental services; however, none have attempted to simultaneously compare the relative influence of demographic, socioeconomic, and ecological variables. Therefore, the present study was undertaken to accomplish this task.

This study expands on earlier efforts to explain variations in the intra-urban distribution patterns of health services. It focuses on dental services and attempts to provide empirical support for the general proposition that factors such as land use and transportation are far more important in explaining variations in the intra-urban supply and distribution of dental services than population size, density, and general characteristics. Other investigators have shown that differences among census tracts regarding the location of dental services can be attributed to the socioeconomic characteristics of the populations residing in the tracts. My view is that this is not the case in urban areas, and that locational decisions are often based on factors such as the availability

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of offices, public transportation, and parking rather than knowledge of the characteristics of the population residing in the vicinity of the site being considered for a dental office.

To support the preceding proposition, I (a) describe the intra-urban distribution of dental services for a single metropolitan area, (b) relate these patterns to selected social and environmental characteristics of specific geographic subunits, and (c) statistically examine the proposition that dental services tend to cluster in areas where other services, especially health services, are located and that this clustering phenomenon is more directly related to environmental factors such as land use, convenience, and access than population characteristics.

Study Methods

The study was conducted in the Hartford, Conn., Standard Metropolitan Statistical Area (SMSA). All data were obtained from secondary sources. Information on dental manpower was taken from official documents of the Connecticut State Dental Commission and compared with local telephone directories to reduce registration errors. Data on the population and its social and economic characteristics were obtained from 1970 census records and local agencies which had compiled statistics for various reasons. Finally, data on transportation and land use were obtained from local planning and transportation agencies.

Three variables used in this study were selected on the basis of previous studies, and several new variables were introduced to facilitate the present analysis. For example, percentage nonwhite, population density, and ratio of dentists to population have been used previously; however, for this study they are used somewhat differently, according to a method developed by Stockwell (11). On the other hand, new variables depicting land use and transportation were developed specifically for this study. The following are the variables used, their abbreviations, and their operational descriptions:

Business use (BUS): percent economic activity devoted to business use (computed from land use records)

Transportation (TRANS): number of bus trips per day passing through census tract (computed from bus company records)

Socioeconomic status (SES): composed of occupational level, family income, and educational level (areas ranked according to relative score)

Percent nonwhite (PNW): taken directly from census records

Residential office (RO): percent activity devoted to residential office use (computed from land use records)

Industrial (INDUS): percent activity devoted to industrial use (computed from land use records)

Population density (DENS): density per square mile (taken directly from census records)

Commercial (COMM): percent land use devoted to commercial purposes (computed from land use records)

Residential (RESID): percent land use devoted to residential purposes (computed from land use records)

Dentists (RATIO): ratio of dentists to population (computed from manpower reports)

The census tract was the unit of analysis used in this study. There were two reasons for this choice: (a) census tracts provide a convenient source of data from census records and a simple method for coding and arranging other variables and (b) the census tract is a widely used unit of analysis for urban ecological analyses.

In addition, the analysis was limited to the town of Hartford, rather than extended into the other towns in the Hartford SMSA. Hartford is the capital of Connecticut and the major retail trade and business center for its 27-town SMSA, and as such it represents the core city. The city's principal industries are insurance, banking, food processing, and manufacturing. It has four major hospitals and a variety of health care facilities.

The primary reason for focusing this initial study on one town was the limited source of data on some of the variables selected for analysis. In subsequent studies, it may be desirable to obtain the same type of data for the entire SMSA. The present analysis, however, is limited to the 49 census tracts in Hartford.

Specific analysis included simple correlation and regression techniques. Zero-order correlation coefficients were used to determine whether the nine independent variables were actually associated with the supply of dentists and whether these associations were in the predicted direction. A hypothesis was considered to be supported if the correlation coefficient between an independent variable and the supply of dentists was non-zero and the sign was in the predicted direction. Second, beta weight analysis was used to determine the relative influence of each independent variable on the supply of dentists. Beta weights are standardized regression coefficients that are commonly used to compare the direct effects of each independent variable on the dependent variable. In addition, the standard errors of the betas

were analyzed to provide some indications of how much confidence could be placed in the betas obtained. Furthermore, the ratio of beta to its standard errors was computed, according to a technique suggested by Hadden (12) in which any ratio less than 2.0 could be considered trivial. Finally, the multiple correlation coefficient was used to determine whether the nine independent variables accounted for an appreciable amount of the variation in distribution of dentists.

The distribution of dentists among the 49 census tracts varies considerably. Several tracts located in heavily industrialized and commercialized areas have no dentists. Other tracts located near hospitals and professional office buildings contain a relatively large number of dentists.

The following nine hypotheses being examined are based on the concept that dental services in Hartford are clustering in areas where transportation is adequate and land use is devoted to health care and office facilities rather than in areas where the population resides.

H₁: the greater the degree of business use in a census tract, the greater the supply of dental services

H₂: the greater the number of bus trips per day, the greater the supply of dental services

H₃: the higher the socioeconomic status of the residents in a census tract, the lower the supply of dental services

H₄: the greater the percentage of nonwhites in a census tract, the lower the supply of dental services

H₅: the greater the degree of residential office use in a census tract, the greater the supply of dental services

H₆: the greater the degree of industrial land use in a census tract, the lower the supply of dental services

H₇: the greater the population density in a census tract, the lower the supply of dental services

H₈: the greater the degree of commercial land use in a census tract, the lower the supply of dental services

H₉: the greater the degree of residential land use in a census tract, the lower the supply of dental services

Findings

A matrix of correlations among the variables used in the analysis (table 1) indicates that the hypotheses for business use and transportation and the supply of dentists are supported by the zero-order correlations. Additionally, the hypotheses for population density and residential use also receive some support. The remaining hypotheses, however, do not appear to receive any support from the zero-order correlation coefficients. These findings suggest that land use and transportation may in fact be more important determinants of dental manpower distribution than the social and demographic characteristics of the population residing in census tracts.

While the zero-order correlation coefficients reveal the existence or lack of existence of associations, such associations may possibly arise through the co-action of several variables. To determine the independent effects of each variable, beta weight analysis was used to control for the other variables. The beta weight analysis among the nine independent variables and the distribution of dentists among the 49 census tracts are summarized in table 2. Only three of the variables used in this analysis had ratios of beta to its standard error which exceeded 2. Business use and transportation showed ratios of +9 or more, while residential office use had a negative ratio of -2.55. In addition, the total set of variables explains approximately 67 percent of the variance in supply of dentists among the 49 census tracts.

Discussion and Conclusions

This study has provided empirical evidence that the availability of public transportation, zoning, and land use are important determinants of where dentists locate in a city. Both the zero-

Table 1. Matrix of correlations among variables for Hartford, Conn.

Variables	(1) BUS	(2) TRANS	(3) SES	(4) PNW	(5) RO	(6) INDUS	(7) DENS	(8) COMM	(9) RESID	(10) RATIO
(1) Business use (BUS)	1.00	.552	-.200	-.149	-.037	-.194	-.218	-.089	-.329	.740
(2) Transportation (TRANS)		1.00	-.281	-.176	.285	.006	-.254	-.047	-.510	.641
(3) Socioeconomic status (SES)			1.00	-.631	.168	-.274	-.223	-.328	.347	-.101
(4) Percent nonwhite (PNW)				1.00	-.132	.168	.098	.307	-.029	-.087
(5) Residential office (RO)					1.00	-.132	-.006	-.116	-.533	.000
(6) Industrial (INDUS)						1.00	-.262	.387	-.410	-.083
(7) Population density (DENS)							1.00	-.103	.250	-.293
(8) Commercial (COMM)								1.00	-.270	-.097
(9) Residential (RESID)									1.00	-.310
(10) Dentists (RATIO)										1.00

Table 2. Summary of multiple regression and correlation analysis among nine independent variables and the supply of dentists for Hartford, Conn.¹

Variables	Standardized regression coefficient (beta)	Standard error of beta	Ratio of beta to standard error
(1) Business use (BUS).....	² .603	.061	9.89
(2) Transportation (TRANS).....	² .525	.053	9.91
(3) Socioeconomic status (SES).....	.159	.093	1.71
(4) Percent nonwhite (PNW).....	.141	.072	1.96
(5) Residential office (RO).....	² -.130	.051	-2.55
(6) Industrial (INDUS).....	.095	.062	1.53
(7) Population density (DENS).....	.077	.041	1.88
(8) Commercial (COMM).....	-.036	.044	-0.82
(9) Residential (RESID).....	-.052	.046	-1.13

¹ Coefficient of determination (R²) = .669

² Beta exceeds its standard error by a factor of 2.0 or more.

order correlation coefficients and the beta weight analysis tended to support the hypothesized relationships. These findings indicate that dentists in Hartford are selecting locations which are convenient to public transportation and where facilities are available for the practice of dentistry. The dentists do not appear to be locating in densely populated areas or areas zoned for purposes other than business; they also seem to be avoiding areas zoned for residential office use, as indicated by the beta weight analysis.

One explanation for these findings may be that dentists in Hartford are providing services for population groups living outside of the town. In fact, in a recent survey it was found that 46 percent of the patients of Hartford dentists were from outlying towns (13); this may be one reason why these dentists select locations convenient to transportation. However, it does not explain the strong association found in the present study between public transportation and the supply of dentists because the buses in Hartford serve only local population groups.

The strong association between land use and the supply of dentists is not surprising. Dentists and other professionals often seek locations where adequate facilities are available and where other professional colleagues are practicing. It is particularly important that prospective dental office sites have adequate electrical and plumbing systems to support the special needs of dental operatories. Thus, buildings designed to accommodate these needs are more desirable.

As predicted, the social, demographic, and economic characteristics of the census tracts are not associated with the supply of dentists. This finding supports the concept that location decisions are not necessarily based on considerations of the population residing in the immediate vicinity of the dental practice as well as the observations of others regarding the decline of neighborhood professional practices and the growing trend toward clustering and centralization of health professionals in certain areas of a city. Physicians' offices are usually clustered around hospitals and clinics, and the same appears to be true of dental practices.

Although the findings from this study lend support to the hypothesized relationships described, it is recognized that generalizations to other cities and towns cannot be made until further studies are conducted. It is also recognized that a census tract analysis within a medium-sized city has certain limitations. Regardless of the limitations of the present study, it has demonstrated that ecological and urban geographic factors need more consideration when analyses of the distribution of dental manpower are performed.

The findings of the present study suggest that future analyses should focus more attention on the distribution patterns for dental services in terms of their relative accessibility to patients by public transportation lines and to the implications of centralizing dental care facilities within national or planned service areas. The town of

Hartford appears to represent the center of a dental service area which draws patients from outlying towns. Although one could argue that dental services should be distributed according to population density, this should not be the only factor.

Analysis such as the one performed in this study could be used as a basis for determining how local dental manpower might be more equitably distributed to make it accessible to all population groups. For example, if we find that the availability of public transportation is not associated with the supply of dentists, attention could then be focused on either providing transportation or placing dentists in locations which are more convenient to the population. Further, if we find that dentists are not locating in areas where zoning regulations deter the location of dental practices, then we could recommend zoning changes. Finally, if we find that dentists are locating primarily in high socioeconomic areas, rather than in high density areas, or in areas where their practices are most accessible, then changes in their distribution patterns could be recommended.

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A study was conducted which simultaneously examined the influence of demographic, socioeconomic, and ecological variables on variations in the distribution of dental practitioners among census tracts in Hartford, Conn. Data were obtained from secondary sources and categorized by census tracts. Nine hypotheses were formulated and examined by multiple correlation and regression techniques. Independent variables included five

measures of land use (business use, residential office, industrial, commercial, residential), transportation, population characteristics, and population density. Four of the hypotheses were supported in the simple correlation analysis, but only three were supported in the beta weight analysis. Also, the total set of nine independent variables explained 67 percent of the variance.

It was concluded that land use and transportation have more in-

fluence on variations in the distribution of dentists in Hartford than population density or composition or socioeconomic characteristics. The inconsistency of these findings with those from other studies suggests a need for more attention to the influence of ecological factors in the study of manpower distribution patterns in future research and planning.